MISSOURI DEPARTMENT OF TRANSPORTATION
MATERIALS ENGINEERING
Jefferson City, Missouri

Test Method
MoDOT T41
DENSITY TESTING OF BITUMINOUS MIXTURES WITH NUCLEAR GAUGES

1.0 SCOPE

This test method establishes the procedure for density testing of bituminous mixtures with nuclear gauges. These procedures apply to the direct transmission nuclear test rode: used for (1) plant mix bituminous base, (2) Type C or D asphaltic concrete mixtures constructed in layers 2 inches thick or thicker, and (3) for Type B asphaltic concrete only when used in lieu of plant mix bituminous base in layers 2 inches thick or thicker and to the backscatter nuclear test mode used only for Type C or D asphaltic concrete mixtures constructed in layers less than 2 inches thick.

2.0 APPARATUS

2.1 Nuclear gauges meeting the apparatus and precision requirements of ASTM D 2950-74.

2.2 Equipment required to determine specific gravity of compacted bituminous mixtures.

2.3 Drilling equipment capable of obtaining 4 inch diameter undisturbed cores from the bituminous mixtures.

3.0 PROCEDURES

3.1 Tests shall be performed in accordance with ASTM D 2950-74 except that Section 3 shall be deleted and a correction factor determined for each mixture.

3.2 Direct transmission tests shall be made at a sufficient depth to test the entire lift. Testing depth shall be the next probe increment greater than the lift thickness when the lift thickness and depth increment do not coincide.

4.0 CORRECTION FACTOR DETERMINATION

4.1 Obtain the required number of tests from within an area of the compacted mixture for the width being laid by at least 400 feet in length for the direct transmission method and at least 650 feet in length for the backscatter method.

Note 1 - Material within one foot of an edge or joint shall not be tested.

4.2 Test sites, one per increment, shall be randomly selected both longitudinally and transversely by use of a table of random numbers such as shown in Exhibit A and explained in Appendix 1. An increment equals the length of test area divided by the required number of tests. At each nuclear test site obtain a core for specific gravity determination. The core site should be located between the source and detectors of the nuclear gauge so hat the same material is tested.

4.3 The minimum number of tests required to establish the correction factor are 16 tests for the backscatter mode and 4 tests for the direct transmission mode.

4.4 A new correction factor shall be determined when here is a change in the job mix, a change in the source of materials or in the material from the same source, a change from one gauge to another or when there is any other reason to believe that the correction factor is in error.

5.0 COMPLIANCE TESTING

5.1 Compliance tests shall be performed in lots. Lots shall be selected 1,000 feet in length by the normal width being constructed, from each 500 tons of the constructed mixture (Note 1).

5.2 Test sites shall be randomly located both longitudinally and transversely by use of a table of random numbers. One random test site shall be selected in each 200 foot increment of the lot for a total of 5 test sites. A nuclear density test by the appropriate method for the mixture should be performed at each test site while the mixture is amenable to rolling.

6.0 SAMPLING

6.1 A compacted sample shall be taken every second day except when production exceeds 3,000 tons per day in which case a sample shall be taken daily. A compacted sample shall consist of four cores for layers 4 inches thick or less and two cores for layers over 4 inches thick. The cores shall be taken directly under the nuclear density testing device between the source and detectors. The compacted sample shall be submitted to the Central Laboratory for testing.

7.0 CALCULATIONS

7.1 Correction factor (C.F.)

$$C.F. = N_d - C_d$$

Where:

N_d = Average nuclear gauge density in pcf

C_d = Average core density in pcf = specific gravity x 62.4 pcf

Note 2: When $N_d > C_d$ subtract C.F.
When $N_d < C_d$ add C.F.

7.1.1 Determine all values to nearest 0.1 pcf.

7.2 Percent compaction

$$\text{Percent compaction} = \frac{100\ CN}{\text{"d" (62.4 pcf)}}$$

Where:

CN = corrected nuclear density in pcf (Average of 5 Tests)

"d" = specific gravity of a laboratory compacted specimen made in the proportions of the approved mixture

7.2.1 Determine corrected nuclear density to nearest 0.1 pcf.

7.2.2 Report percent compaction to the nearest whole percent.

APPENDIX 1

The test procedure requires that test sites both for determining the nuclear gauge correction factor and for compliance testing be randomly located by using the table of random numbers, Exhibit A.

Paragraphs 4.1 and 5.1 of the test procedure give the dimensions of the test area and lot, respectively. Note 1 excludes material from within one foot of an edge or joint from testing. The length of the area or lot will not be affected by Note 1 provided the first and last foot of the days operation are excluded from consideration; however, the test width will always be two feet less than the width being laid because one foot on each side is excluded from testing.

An example of the use of the table of random numbers for compliance testing follows:

The first step is to select a lot 1,000 feet in length by the width (assumed to be 12 feet) being laid. The lot can be selected from anywhere within the area covered by 500 tons of the constructed mixture. The lot is then divided into 5 increments each 200 feet in length. Note the beginning station number of each increment.

The second step is to select the required sets of numbers from the table of random numbers, Exhibit A. Start at any point in the table and, proceeding up or down, pick 5 successive sets of numbers. Once a starting point and direction in the table are chosen, successive pairs of numbers are selected. Skipping pairs of numbers or reversing the direction is not permitted. Should a test site be judged unfit for testing, the next pair of numbers in the table is chosen to locate an alternate site within the increment. Also, should all the pairs of numbers be used on a project, continue through the table of random numbers in the same direction without skipping.

The third step is to compute the location of the test sites. An example follows:

Step 1:

Test lot begins at Station 200+00 and ends at Station 210+00. Required number of tests is 5.

Testing increment is 1,000 feet divided by 5 or 200 feet. Test width is 10 feet (exclude one foot from each side of the 12 foot width being laid).

Step 2:

Select 5 successive sets of numbers from the able of random numbers. Start with the 6th number in column 2 and proceed down. (The fact that each block has 5 sets of numbers has no significance.)

Numbers Selected

A	B
.554	.627
.225	.163
.035	.039
.334	.921
.576	.417

Step 3:

COMPUTATION OF TEST STATION

Station of Beginning of Increment	Test A x Increment		Station
200+00	+ (.554 x 200')	=	201+11
202+00	+ (.225 x 200')	=	202+45
204+00	+ (.035 x 200')	=	204+07
206+00	+ (.334 x 200')	=	206+67
208+00	+ (.576 x 200')	=	209+15

COMPUTATION OF OFFSET

B x Test Width		Offset*
.627 x 10'	= 6.3'	7.3'
.163 x 10'	= 1.6'	2.6'
.039 x 10'	= 0.4'	1.4'
.921 x 10'	= 9.2'	10.2'
.417 x 10'	= 4.2'	5.2'

* Offset includes the one foot exclusion between test site and measurement reference (centerline or edge). Also, the width of a previously laid pass can be included.

RANDOM NUMBERS

1		2		3		4		5	
A	B	A	B	A	B	A	B	A	B
.576	.730	.430	.754	.271	.870	.732	.721	.998	.239
.892	.948	.858	.025	.935	.114	.153	.508	.749	.291
.669	.726	.501	.402	.231	.505	.009	.420	.517	.858
.609	.482	.809	.140	.396	.025	.937	.310	.253	.761
.971	.824	.902	.470	.997	.392	.892	.957	.640	.463
.053	.899	.554	.627	.427	.760	.470	.040	.904	.993
.810	.159	.225	.163	.549	.405	.285	.542	.231	.919
.081	.277	.035	.039	.860	.507	.081	.538	.986	.501
.982	.468	.334	.921	.690	.806	.879	.414	.106	.031
.095	.801	.576	.417	.251	.884	.522	.235	.398	.222
.509	.025	.794	.850	.917	.887	.751	.608	.698	.683
.371	.059	.164	.838	.289	.169	.569	.977	.796	.996
.165	.996	.356	.375	.654	.979	.815	.592	.348	.743
.477	.535	.137	.155	.767	.187	.579	.797	.358	.595
.788	.101	.434	.638	.021	.894	.324	.871	.698	.539
.566	.815	.655	.548	.947	.169	.817	.472	.864	.466
.901	.342	.873	.964	.942	.985	.123	.086	.335	.212
.470	.682	.412	.064	.150	.962	.925	.355	.909	.019
.068	.242	.667	.356	.195	.313	.396	.460	.740	.247
.874	.420	.127	.284	.448	.215	.833	.652	.601	.326
.897	.877	.209	.862	.428	.117	.100	.259	.425	.284
.875	.969	.109	.843	.759	.239	.890	.317	.428	.802
.190	.696	.757	.283	.666	.491	.523	.665	.919	.146
.341	.688	.587	.908	.865	.333	.928	.404	.892	.696
.846	.355	.831	.218	.945	.364	.673	.305	.195	.887
.882	.227	.552	.077	.454	.731	.716	.265	.058	.075
.464	.658	.629	.269	.069	.998	.917	.217	.220	.659
.123	.791	.503	.447	.659	.463	.994	.307	.631	.422
.116	.120	.721	.137	.263	.176	.798	.879	.432	.391
.836	.206	.914	.574	.870	.390	.104	.755	.082	.939
.636	.195	.614	.486	.629	.663	.619	.007	.296	.456
.630	.673	.665	.666	.399	.592	.441	.649	.270	.612
.804	.112	.331	.606	.551	.928	.830	.841	.602	.183
.360	.093	.181	.399	.564	.772	.890	.062	.919	.875
.183	.651	.157	.150	.800	.875	.205	.446	.648	.685

EXHIBIT A